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Evaluating the transformation of China's industrial development mode during 2000–2009

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A R T I C L E I N F O

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A B S T R A C T

Following the global trend of sustainable development, the concepts of transformation of industrial development mode and "the New Road to Industrialization with Chinese Characteristics" were proposed in China around the year of 2000. Today, the transformation has been carried out for 10 years, and the effects and problems as well as experiences are worth discussing. This research aims to establish an index system of China's industrial transformation. The weight of each indicator which is in the index system is calculated by the two methods: entropy weight and analytic hierarchy process (AHP), respectively, for the purpose of high reliability. The transformation from 2000 to 2009 is evaluated by the method of weighted average. The results demonstrate that China's industrial development mode has been changing progressively. However, a number of problems still remain, for instance, China's ability of withstanding external crises is still weak, the situation of human capital is still unable to meet the needs of transformation, the conversion rate of independent innovation achievements is low, the effect of industrial structure adjustment is unsatisfactory, the housing price is relatively high, and also the rich-poor divide in China posts a great threat. Then, several suggestions related to the problems mentioned above are put forward. The development of index system and methods are aimed to form a set of useful tools for policy-makers to facilitate the transformation of industrial development mode and support sustainable development.

Contents

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1. Introduction

Since the First Five-Year Plan (1953–1957), China has followed Stalin's "socialist industrialization route", which focuses on manpower, material resources and financial resources to develop heavy industry, but it loses sight of production efficiency [1–3]. During the three decades since, China has undergone the full bloom of economic growth [2]. However, the rapid growth of heavy industry has brought a series of problems. China's economy presents the characteristics of extensive growth and is mainly driven by significant inputs of capital, energy, raw materials and labors. Total Factor Productivity (TFP) and technical progress make few contributions to economic growth [4]. Take the energy consumption per unit of GDP as an example, according to the data of the National Bureau of Statistics of China from 2000 to 2008 (Fig. 1), the energy consumption per unit of GDP in China is generally higher than the levels of high income countries and middle income countries, and even higher than the world average level. The figure in 2008 was 8.2 times than that of Japan and four times than that of the United States. Now, the problem of pollution is of extreme serious in China. According to the Annual Report on Environment Development of China, about 43% of water resources was unsuitable for humans, and the phenomenon of acid rain existed in 52.9% of the observed cities in 2010 [5].

At the same time, the extensive growth has attracted concerns from all the countries and regions. Sustainable development was popularized in Our Common Future, a report published by the World Commission on Environment and Development in 1987 [6]. Over the past 20 years, the relationship among environment, resources, climate and economic activities has been discussed [7], and the need to integrate environmental considerations into development policymaking has been pointed out constantly. With the global flow of sustainable development becoming a major trend, industrial development mode and economic issues related to green practices have gained wide attention [8].

Today, following the global trend of sustainable development, China also attaches great importance to the harmonious development of economy, society, population and environment. Since the concept of "the New Road to Industrialization with Chinese Characteristics" was first put forward clearly by the 16th National Congress of the Communist Party of China in 2002 [9], the transformation of China's industrial development mode has been put into practice for 10 years. A number of issues are worth discussing, such as, whether China's industrial development pattern has been changed as well as what are the effects, problems and experiences in the process of transformation.

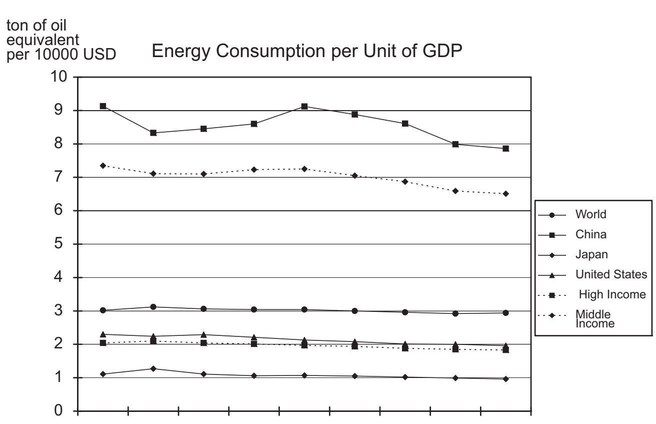


Fig. 1. Energy consumption per unit of GDP.
Source: the National Bureau of Statistics of China.

However, only few people think about these problems so far. What the Chinese scholars and government officials have done were only comparing some relevant data and conducting generic normative analysis as well as proposing some general suggestions. Only few researchers focus on long-term study, and even there is no methodology to evaluate the transformation. However, this work needs to be done.

Based on the current situation of China's industrial development and wide discussions from domestic and foreign scholars on sustainable development and economic transformation, this paper builds an evaluation framework, designs a set of tools and evaluates China's industrial development mode for the first time. These efforts are expected to discuss problems mentioned above and fill the gap in the studies on economic transformation. Meanwhile, as a developing country and a typical example of extensive economic growth, our evaluation method, conclusions and experience are of significance to other countries.

2. Literature reviews

2.1. Sustainable development and the transformation of industrial development mode

The concept of sustainable development was defined formally for the first time in the report of Our Common Future by the World Commission on Environment and Development in 1987 [10]. Sustainable development includes not only traditional economic growth but also the harmonious relationship among human, resources and environment [11]. Since then, the concepts such as sustainable development, green economy, the transformation of traditional economic development mode have been expanded and attracted wide attention [12–15]. In 2002, the concept of "the New Road to Industrialization with Chinese Characteristics" was put forward clearly for the first time. Its characteristics are driving industrialization by informatization and in turn, promoting informatization by industrialization, blazing a new road to industrialization featuring high-tech content, high returns, low resources consumption, less environmental pollution and a full display of the advantages in human resources [9]. In the Twelfth Five-Year Plan for National Economic and Social Development of the People's Republic of China, the transformation of economic development pattern is the top priority. The highlights of transformation in the plan are stable economic growth, industrial structure adjustment, scientific and technological progress, innovation, people's well-being, resources and environment [16].

Since the book *The Wealth of Nations*, written by British economist Adam Smith, was published in March 1776, academe sphere has drawn extensive studies on economic growth for 200 years and has reached an agreement that the productive resources (including human capital and other intangible capitals) as well as scientific and technological progress are the decisive factors of economic growth [17–21]. Additionally, human development and education are considered to act as an essential role in determining sustained growth trajectories [22,23]. Tertiary education plays a more important role than primary and secondary education on economic growth [24]. Research and Development (R&D) spending is also a critical input into economic growth, a 10% increase in R&D per capita generates an average increase of about 1.6% in the long-term TFP [25]. Domestic technology purchases are found to have a favorable direct impact on innovation and importing foreign technology alone does not facilitate innovation unless in-house R&D is also conducted [26]. In summary, successful policies should focus on human development, R&D spending, import of foreign technology, domestic

technology purchases and absorptive capacity. By connecting these economic growth theories, a conclusion can be seen. Each theory originates from its own background and the evolution of these theories actually shows the change of economic development mode.

2.2. The evaluation of the transformation

Many scholars have started to evaluate sustainable development and the methods which have been developed all have distinctive features [27–30]. Most strive for sustainable development in factors including society, economics, ecology and environment [31], however, there are few studies on evaluating the transformation of economic development mode. In China, Li and Zhang [32] established an index system from four aspects: the behavior of economic operation, the development power, the adaptation of development constraints and the share of achievements. They measured the transformation from 2000 to 2009 and found the basic conclusion that China's economic development mode had been changed gradually. However, the index system lacks the object of human capital which is an important part in the transformation. Moreover, the method which they choose to determine the weights of indicators is not scientific.

In a word, people have realized the significance of sustainable development and the transformation. But there are no effective methods and indicators for the evaluation of transformation. This paper aims to establish a more comprehensive evaluation index system which includes economic foundation, human capital situation, independent innovation capability, industrial structure adjustment and upgrading, people's living standards as well as resources and environment. The weights of indicators are determined by the two methods: entropy weight and analytic hierarchy process (AHP), respectively. The mode from 2000 to 2009 is evaluated by the method of weighted average. The development of evaluation index system and methods for the transformation would make contributions to harmonious and sustainable development.

3. Material and methods

3.1. Evaluation objects

Based on the above research, this paper would interpret the transformation of China's industrial development mode as follows:

(1) Economic growth is the foundation of transformation. Economic growth is an important symbol of a country's economic power and the basis of human activities and social development. It is also a great impetus to a country's prosperity, improvement of people's living standards as well as progress of social civilization. Although rapid economic growth brings many problems, most countries still consider growth as the core target of economic policies [33]. Hence, there is no doubt that economic growth is also the foundation of transformation. It is unrealistic to study the transformation without taking economic growth into consideration.

(2) Human capital, independent innovation as well as industrial structure adjustment and upgrading are the driving forces of transformation. They are important factors of enhancing economic sustainable development ability and the powerful impetus of facilitating transformation [16]. Currently, China's general labor is abundant, the personnel in technology, knowledge and management are relatively less, and the entrepreneurs with creative spirit are seriously lack in China [34]. This pyramid structure of human capital is unable to meet the needs of industrial structure adjustment and upgrading. Independent innovation is the driving force of ensuring a country's sustainable growth and improving its competitiveness continuously. It reflects the ability of creating science and technology, grasping the core technology and realizing the commercialization of innovation achievements [35]. At present, China's ability of independent innovation is still not strong. For example, the levels of the high-tech industries as well as the conversion rate of innovation achievements are both low, R&D investment is insufficient in total and its structure is illogical, the protection of intellectual property rights is unsatisfactory [35]. Industrial structure adjustment and upgrading is mainly manifested in eliminating the high pollution, high energy consumption and low benefit industries and constantly expanding the high technology and high benefit industries. It also requires our government to promote industrial development and improves industrial profits by merging industrialization and informatization gradually.

(3) The purposes of transformation are improving people's living standards and saving resources as well as protecting environment. The constant improvement of people's living standards is the ultimate goal of transformation. It is also the important embodiment of sharing the achievements of social progress [32]. The improvement is mainly manifested in the continuing improvement of income levels, consumption levels, the standards of living, education, health care and social insurance. In the mean time, resources conservation and environmental protection are the important guarantees of the improvement of people's living standards. Due to the large population in China, the per capita amount of resource is inadequate and the ecosystem is fragile, the Chinese government has attached great importance to resource conservation and environmental protection.

3.2. Index system

According to above three aspects, an index system is established as shown in Table 1.

The index system is divided into three parts which are connected by progressive logic: economic foundation of transformation, approaches of transformation and purposes of transformation.

The first part is the foundation. It includes one second-level indicator, two third-level indicators and two specific indicators. Because of the both relevant and differential relationship between overall economic operation and industrial economic operation, we select "Gross domestic product at constant prices" and "Industrial growth rate of industrial enterprises above designated size" as two specific indicators, which represent the situation of both economic growth and industrial growth from two aspects: scale and speed. They are expected to reflect the foundation comprehensively.

The second part is the approaches. It includes three second-level indicators, eight third-level indicators and 17 specific indicators. In the aspect of human capital, this paper selects the specific indicators, which indicate the relationship of input (including funds and manpower) and output (including scale and structure), to reflect the conditions of human capital investment, human capital scale and human capital structure. In the aspect of independent innovation, five specific indicators which also indicate the relationship of input (including the expenditure and manpower paid for R&D) and output (including the economic value and amount of the achievements) are chosen to reflect the ability of independent innovation in China. In the aspect

Table 1
The index system for evaluating the transformation of China's industrial development mode.

Top	Second-level	Third-level	Specific indicators
Foundation	Economic growth	Overall economic operation	1. Gross domestic product at constant prices (100 million yuan)
		Industrial economic operation	2. Industrial growth rate of industrial enterprises above designated size (%)
Approaches	Human capital	Human capital investment	3. Government appropriation for education/GDP (%) 4. Number of full-time higher education teachers (10 000 persons)
		Human capital scale	5. Annual average number of employees in industrial enterprises above designated size (10 000 persons)
		Human capital structure	6. Number of professional technical personnel/ Employment (%) 7. Number of science and technology personnel/ Employment (%)
	Independent innovation	Independent innovation input	8. Intramural expenditure on R&D in large and medium-sized industrial enterprises/Sales revenue (%) 9. Full-time equivalent of R&D personnel in large and medium-sized industrial enterprises (10 000 man-years)
		Independent innovation output	10. Volume of transaction in technical markets(100 million yuan) 11. Number of patents application accepted(10 000 pieces) 12. Degree of dependence on domestic technology (%)
	Industrial structure adjustment and upgrading	Industrial structure adjustment	13. High-tech industry output value/Output value of industrial enterprises above designated size (%) 14. Output value of the top six high energy consumption industries above designated size/Output value of industrial enterprises above designated size (%)
		Industrial upgrading	15. Expenditure for purchase of technology in large and medium-sized industrial enterprises/Sales revenue (%) 16. Expenditure for assimilation of technology in large and medium-sized industrial enterprises/ Sales revenue (%) 17. Profit growth rate in industrial enterprises above designated size (%)
		Informatization construction	18. Number of internet users (10 000 persons) 19. Popularization rate of telephone (include mobile telephone) (sets/100 persons)
Purposes	People's living standards	Income	20. Income growth rate/GDP growth rate (%)
		Housing	21. Per capita building space in urban areas (sq m)
		Transportation	22. Number of public transportation vehicles per 10 000 population in city (unit)
		Health care	23. Number of licensed (assistant) doctors per 10 000 population (person)
		Education	24. Percentage of higher education (%)
		Social insurance	25. Percentage of joining urban basic pension insurance (%)
	Resources and environment	Energy saving	26. Energy consumption per unit of GDP (ton of SCE/10 000 yuan)
		Environmental protection	27. Industrial pollution emissions per unit of GDP (per unit/100 million yuan)

Note: The calculation of the indicator 12 adopts the method in Ref. [32], degree of dependence on domestic technology = expenditure for purchase of domestic technology in large and medium-sized industrial enterprises/expenditure for purchase of technology in large and medium-sized industrial enterprises. The top six high energy consumption industries in the indicator 14 are smelting and pressing of non-ferrous metals, smelting and pressing of ferrous metals, manufacture of non-metallic mineral products, processing of petroleum, coking, processing of nuclear fuel, production and supply of electric power and heat power, manufacture of raw chemical materials and chemical products. Expenditure for purchase of technology in the indicator 15 includes expenditure for acquisition of foreign technology and expenditure for purchase of domestic technology. Industrial pollution emissions in the indicator 27 are the sum of the emission of industrial waste water, industrial waste gas and industrial solid wastes. The change of the emissions scale is only considered in this paper.

of industrial structure adjustment and upgrading, seven specific indicators are selected, which are the most typical indicators of industrial structure adjustment and upgrading as well as informatization construction in China. The choice of these indicators aims to reflect the power of transformation comprehensively.

The third part is the purposes. It includes two second-level indicators, eight third-level indicators and eight specific indicators. We select the specific indicators, which are the most basic features of people's life and resource conservation as well as environmental protection from the aspects of income, housing, transportation, health care, education, social insurance, energy consumption and industrial pollution emissions, to evaluate the achievements of transformation.

All the specific indicators are the most basic and typical indicators, which would reflect the most concerned aspects of transformation exactly. These indictors can allow people to have a more comprehensive understanding of China's industrial transformation. Moreover, because China's statistical indicators are not completed at present, these indicators we choose are based on the principle of easy obtaining. This principle can facilitate further calculation and evaluation below. With the extension of China's statistical indicators, these specific indicators can be adjusted and expanded in the future gradually.

3.3. Data sources and preprocessing

The original data in this paper are derived from *China Statistical Yearbook* [36] and the column of science & technology statistics in the website of Ministry of Science & Technology of the People's Republic of China [37].

The original data matrix ($X' = (x'_{ij})_{m\times n}$, m represents years and n represents the indicators in the index system, x'_{ij} is the original data for year i with respect to indicator j, $i = 1,\ldots,m$; $j = 1,\ldots,n$) is established by the original data. Because of the different units of these indicators, the original data must be normalized and adjusted in the range of 0–1. This is achieved by normalizing every element in the original data matrix X' into a corresponding element in the normalized data matrix $X = (x_{ij})_{m\times n}$ using the following formulas:

$$x_{ij} = \frac{x'_{ij} - x_j^{\min}}{x_j^{\max} - x_j^{\min}},\ i = 1,\ldots,m;\ j = 1,\ldots,n, \text{ for benefit attribute} \quad (1)$$

$$x_{ij} = \frac{x_j^{\max} - x'_{ij}}{x_j^{\max} - x_j^{\min}},\ i = 1,\ldots,m;\ j = 1,\ldots,n, \text{ for cost attribute} \quad (2)$$

here, x'_{ij} is the original data for year i with respect to indicator j in the original data matrix X' and x_{ij} is the normalized value. $x_j^{\max}$ and $x_j^{\min}$

are the maximum value and minimum value, respectively, for indicator j in the original data matrix X'.

3.4. Methods

The established index system is used to evaluate the transformation of China's industrial development mode from 2000 to 2009. In the process of evaluation, we adopt two typical methods: entropy weight and analytic hierarchy process (AHP), respectively, to determine the absolute weight of each indicator in the index system. Entropy weight method is a common and objective method to determine weights. Entropy is a measurement of the uncertainty in information theory. In the process of evaluation, the more the information of indicators is, the less the uncertainty and entropy are. Therefore, the weight of indicator is greater and vice versa. The specific calculation steps can refer to the Ref. [38]. Analytic hierarchy process method is a very common but subjective method. It is proposed by Thomas L. Saaty from the United States National Academy of Engineering. The specific calculation process can refer to the Ref. [39]. This paper chooses the two methods to determine the weights of indicators because: (a) there may be some deviations by only using one method because of its objective or subjective characteristics. The two methods are used at the same time can remedy the defect by only one of them. (b) Two groups of weights which are determined by the two methods can be contrasted with each other for the purpose of high reliability. (c) We can estimate the correctness of evaluation through comparing two groups of scores of transformation which are calculated by the two groups of weights, respectively. If the same result can be obtained from the two groups of scores, it proves that this evaluation is scientific and reliable. If the evaluation conclusions based on the two groups of scores are widely divergent, it indicates that the effect of evaluation is unsatisfactory and there may have some problems in selecting methods of determining the weights of indicators.

Based on these absolute weights, the relative weight of every indicator will be calculated by normalization method. Combining the normalized values and relative weights, Economic Growth Index (EGI), Human Capital Index (HCI), Independent Innovation Index (III), Structure Adjustment and Upgrading Index (SAUI), People's Living Index (PLI) as well as Resource and Environment Index (REI) are established by the method of weighted average. Based on the absolute weights and normalized values, Industrial Development Mode Index (IDMI) is built by the method of weighted average.

4. Results

4.1. Indicators' weights

Two groups of relative weights and two groups of absolute weights are obtained in Table 2. There are some differences between the two groups of weights, which reflect the different emphases of entropy weight method and analytic hierarchy process method (AHP). Besides, analytic hierarchy process method (AHP) highlights the contributions of human capital and people's living standards.

4.2. Indicators dynamic trends

The dynamic trend of every indicator from 2000 to 2009 is shown in Fig. 2. Most of the trends are relatively stable except "Industrial growth rate of industrial enterprises above designated size" and "Profit growth rate in industrial enterprises above designated size" as well as "Income growth rate/GDP growth rate". The stable trends indicate that the index system can effectively reveal the changing trend of China's industrial development mode.

Table 2
Indicators' weights of the index system obtained by entropy weight method and AHP method.

Second-level	Specific indexes	Entropy weight method		AHP method	
		Absolute weight	Relative weight	Absolute weight	Relative weight
Economic growth	1	0.0323	0.4946	0.0122	0.5000
	2	0.0330	0.5054	0.0122	0.5000
Human capital	3	0.0259	0.0909	0.0367	0.2849
	4	0.0257	0.0902	0.0380	0.2951
	5	0.0315	0.1106	0.0063	0.0489
	6	0.1523	0.5346	0.0193	0.1498
	7	0.0495	0.1737	0.0285	0.2213
Independent innovation	8	0.0329	0.1785	0.0765	0.2371
	9	0.0404	0.2192	0.0765	0.2371
	10	0.0343	0.1861	0.0492	0.1525
	11	0.0361	0.1959	0.0394	0.1221
	12	0.0406	0.2203	0.0811	0.2512
Industrial structure adjustment and upgrading	13	0.0216	0.0980	0.0362	0.2001
	14	0.0349	0.1583	0.0155	0.0857
	15	0.0461	0.2092	0.0228	0.1260
	16	0.0164	0.0744	0.0228	0.1260
	17	0.0376	0.1706	0.0364	0.2012
	18	0.0405	0.1838	0.0236	0.1305
	19	0.0233	0.1057	0.0236	0.1305
People's living standards	20	0.0201	0.1134	0.0631	0.2092
	21	0.0246	0.1388	0.0296	0.0981
	22	0.0219	0.1236	0.0296	0.0981
	23	0.0382	0.2156	0.0598	0.1982
	24	0.0222	0.1253	0.0598	0.1982
	25	0.0502	0.2833	0.0598	0.1982
Resources and environment	26	0.0433	0.6195	0.0207	0.5000
	27	0.0266	0.3805	0.0207	0.5000

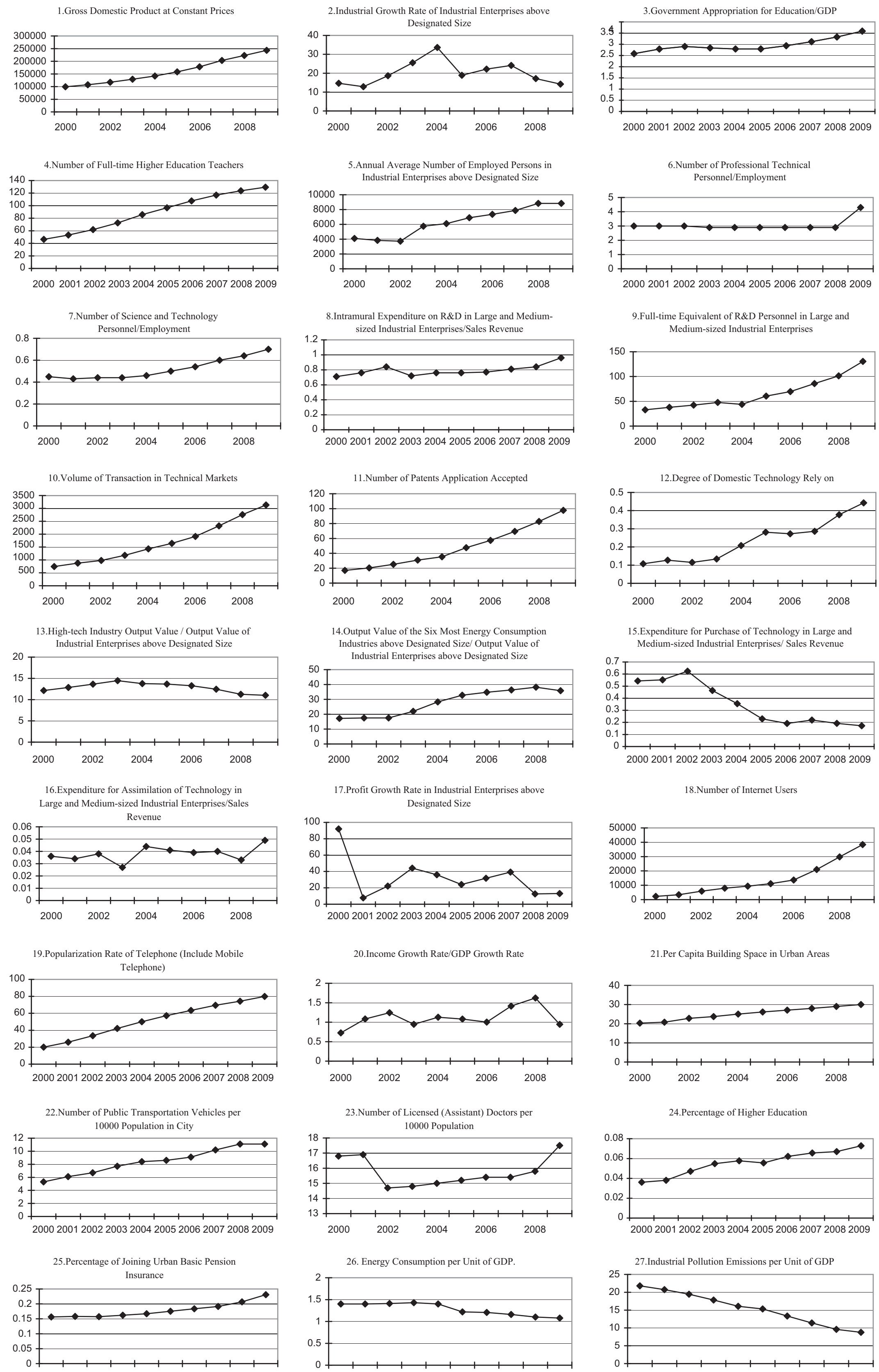


Fig. 2. The dynamic trends of the indicators from 2000 to 2009.

(1) Economic growth. This paper selects the indicators of ‘‘Gross domestic product at constant prices’’ and ‘‘Industrial growth rate of industrial enterprises above designated size’’ to reflect the economic foundation of transformation from two aspects: scale and speed of economic growth. In Fig. 2(1–2), ‘‘China's gross domestic product at constant prices’’ reveals a trend

of increase and reached the maximum value of 24.3 trillion in 2009. However, its growth rate began to decline in 2008. This is caused by the global financial crisis and the transformation of the government's pursuit of economy from quantity to quality. ''Industrial growth rate of industrial enterprises above designated size'' fluctuated repeatedly. It decreased twice in 2005 and 2008 after reaching the maximum value of 33.64% in 2004. It was as low as 14.2% in the end of 2009.

(2) Human capital. Human capital is one of the most important factors for transformation. This paper chooses three aspects: investment, scale and structure of human capital to reflect the current situation of China's human capital. In Fig. 2(3–7), we can find that every indicator has a common characteristic in human capital layer. This characteristic can be described as improving slowly from a low level. The expenditure for education and the number of professional technical personnel increased slowly year by year. Relatively, the teaching investment for full-time higher education teachers and the number of employees in industrial enterprises above designated size as well as the number of science and technology personnel increased faster.

(3) Independent innovation. The engine of transformation is reflected from two aspects: the input and output of independent innovation. In Fig. 2(8–12), all the indicators show the trends of continuous improvement, which reflects the achievements of improving the ability of independent innovation. The indicators of ''Volume of transaction in technical markets'' and ''Number of patents application accepted'' as well as ''Degree of dependence on domestic technology'' reflected that the output level of independent innovation was improved significantly. The input of full-time equivalent of R&D personnel in large and medium-sized industrial enterprises in China was huge. It was as high as 130.6 10 000 man-years in 2009, which was four times than the figure in 2000 and ranked the first all over the world [37]. However, the growth rate of ''Intramural expenditure on R&D in large and medium-sized industrial enterprises/Sales revenue'' was relatively slow. It was in line with the low level of ''R&D expenditure in GDP'' which was far below the level of 3.47% in Japan and 3.44% in South Korea.

(4) Industrial structure adjustment and upgrading. This paper evaluates the condition of industrial structure adjustment and upgrading in China from the full-scale view: high technology industries, high energy consumption industries, technical renovation and upgrading as well as informatization construction. In Fig. 2(13–19), the changing trends of most indicators were not optimistic except the informatization indicators. ''High-tech industrial output value to output value of industrial enterprises above designated size'' had no significant increase. It had been falling for 6 years continuously after reaching the highest point of 14.45% in 2003 and the level in 2009 was lower than that of in 2000. The development of high technology industry was unsatisfactory. ''Output value of the top six high energy consumption industries above designated size/Output value of industrial enterprises above designated size'' was increasing gradually from 2000 to 2009. It revealed that the economic growth in China still relied on the high energy consumption industries. Technology importing and assimilation are the important approaches of industrial transformation. The expenditure for purchase of technology in large and medium-sized industrial enterprises in China was increasing slightly from 2000 to 2002 and dropped dramatically from 2003 to 2009. ''Expenditure for assimilation of technology in large and medium-sized industrial enterprises/Sales revenue'' was always between 0.03% and 0.04% from 2000 to 2009. Moreover, it can be seen in *China Statistical Yearbook* that the percentage of enterprises having R&D activities to total number of enterprises also did not increase obviously in those years [36]. This fully explained that the industrial upgrading did not make substantial breakthrough. The increase of enterprise profit margin is the main target and important presentation of industrial structure adjustment and upgrading. The profit growth rate in industrial enterprises above designated size revealed a general trend of decrease from 2000 to 2009. It revealed that the achievements of independent innovation did not bring high returns for enterprises and the conversion rate of achievements was not as high as we expected. Only has the informatization construction in China realized the breakthrough. This supports China's industrial upgrading strongly.

(5) People's living standards. This paper adopts the most basic indicators from the aspects of income, housing, transportation, health care, education and social insurance to reflect the standards of living in China. In Fig. 2(20–25), most of the indicators improved continuously which reflected that the standards of living were improved gradually in China. The indicators: ''Per capita building space in urban areas'', ''Number of public transportation vehicles per 10 000 population in city'', ''Percentage of higher education'' and ''Percentage of joining urban basic pension insurance'' improved continuously that reflected people's living standards in the aspects of housing, transportation, higher education and social insurance were improved. ''Income growth rate/GDP growth rate'' revealed a trend of fluctuations. Its figure increased fast during 2000–2002 and 2006–2008 and reached the highest point that was 1.62 times of GDP growth rate in 2008. However, it fell dramatically in 2009 and the level was close to that of 2000. The indicator of ''Number of licensed (assistant) doctors per 10 000 population'' revealed a trend of improving. It began to increase in 2002 and achieved the number of 17.5 in 2009.

(6) Resources and environment. This paper selects the indicators of ''Energy consumption per unit of GDP'' and ''Industrial pollution emissions per unit of GDP'' to reflect the situation of energy conservation and pollution reduction in China. In Fig. 2(26–27), the two indicators showed the trends of decrease. Between them, the reduction of ''Industrial pollution emissions per unit of GDP'' was very obvious. It decreased from 21.79 units in 2000 to 8.76 units in 2009. The effect of energy conservation and emission reduction was remarkable and people's living environment was improved constantly.

4.3. Index dynamic trends

According to the normalized values and the two groups of relative weights, the scores of EGI, HCI, III, SAUI, PLI and REI from 2000 to 2009 are calculated by the method of weighted average. The index dynamic trends are drawn as Fig. 3.

(1) Economic Growth Index (EGI) The scores of EGI from 2000 to 2009 are calculated as shown in Fig. 3a. Two groups of EGI were almost the same, which reflected that the economic foundation of transformation was improved during fluctuations. EGI fell to the lowest point in 2001 and increased continually from 2002 to 2004. In 2005, it eased back and the second growth occurred in 2006. From 2008 to 2009, EGI dropped again because of the global financial crisis. All in all, the economic foundation of transformation revealed a trend of improving during fluctuations. The improvement provides support for the transformation of China's industrial development

mode. However, the repeated fluctuation would make the transformation difficult.

(2) Human Capital Index (HCI) In Fig. 3b, two groups of HCI from 2000 to 2009 are calculated. The scores of the two groups both showed the similar trend, which reflected the situation of human capital was improved gradually. The fastest growth occurred in 2009 and reached the highest point. Since this paper highlights the contributions of human capital by the method of analytic hierarchy process (AHP), the scores of HCI using analytic hierarchy process method (AHP) are generally higher than entropy weight method. In summary, China's human capital is improved gradually, and the improvement is contributive to the transformation of China's industrial development.

(3) Independent Innovation Index (III) In Fig. 3c, two groups of III from 2000 to 2009 are calculated. They were almost the same, which reflected the constant improving trend of independent innovation in the process of transformation. China's III increased gradually from 2000 to 2009. Its rising velocity speeded up after 2003 and reached the highest point in 2009. The input and achievements of independent innovation increased steadily, which promoted the transformation of China's industrial development mode constantly.

(4) Structure Adjustment and Upgrading Index (SAUI) In Fig. 3d, SAUI from 2000 to 2009, revealed a similar trend and the scores were generally not high. It reflected that the effect of industrial structure adjustment was unsatisfactory. The proportion of high-tech industry output value increased sharply and the adjustment of high energy-consuming industry was insufficient from 2000 to 2009. For the more, the profit growth rate in industrial enterprises above designated size declined during the continuous fluctuations. Only was the level of informatization in China improved gradually. In summary, structure adjustment and upgrading in China does not progress smoothly, which could not promote the transformation effectively.

(5) People's Living Index (PLI) In Fig. 3e, PLI from 2000 to 2009 are calculated. The two groups of PLI presented a similar trend, which reflected the improvement of Chinese people's living standards in the process of transformation.

(6) Resource and Environment Index (REI) In Fig. 3f, two groups of REI from 2000 to 2009 were almost the same that reflected the constant improving trend of resources and environment in the process of transformation. China's REI rose gradually from 2000 to 2009 and in 2009 it reached the highest point in those ten years. The energy consumption per unit of GDP and the industrial pollution emissions per unit of GDP reduced gradually. People's living environment was improved and the transformation of China's industrial development mode was promoted.

4.4. Comprehensive evaluation

In Fig. 4, the scores of IDMI from 2000 to 2009 showed the similar trend which reflected China's industrial development mode was changed step by step. From 2000 to 2003, the scores of IDMI revealed that China's industrial development mode was changed gradually. There was a remarkable progress in the transformation from 2004 to 2007. The situation of human capital, the ability of independent innovation, the condition of resources and environment as well as the level of people's life were all improved rapidly. The comprehensive scores still increased dramatically while the economic growth appeared V type of fluctuations. In 2008, under the influence of global financial crisis, IDMI was still constantly improving but its growth

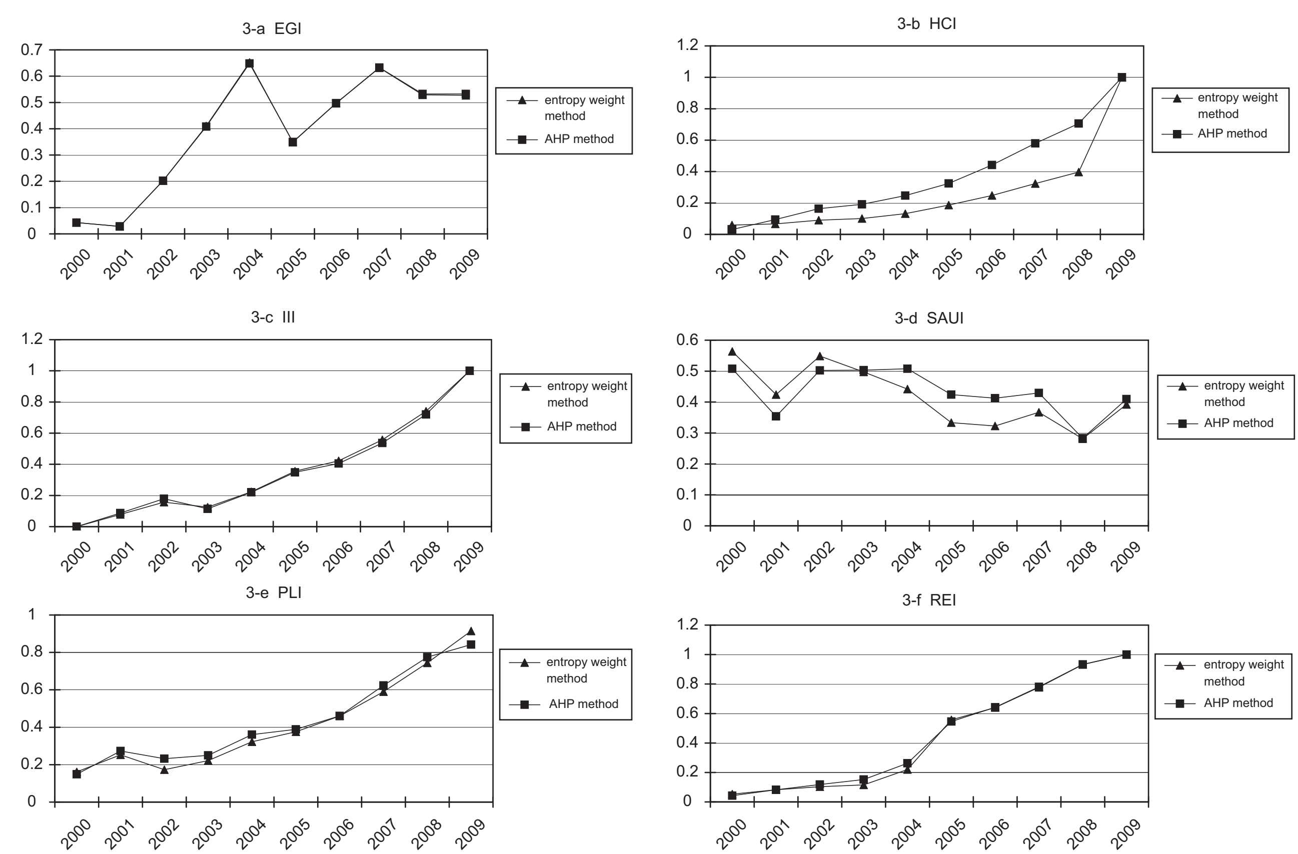


Fig. 3. Index dynamic trends from 2000 to 2009.

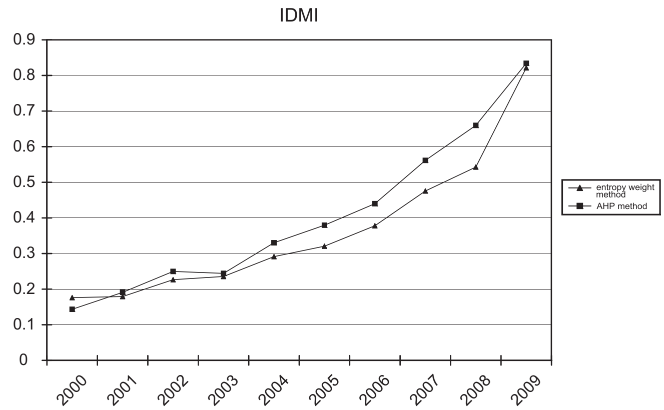


Fig. 4. Comprehensive scores of the transformation from 2000 to 2009.

rate slowed down. In 2009, a series of macroeconomic policies were issued by the Chinese government in order to resist the financial crisis. The transformation of China's industrial development mode was promoted rapidly again.

5. Discussion

This paper establishes an index system to evaluate the transformation of China's industrial development mode during 2000–2009 based on the aspects of economy foundation, approaches and the purposes of transformation, which are connected by progressive logic.

The index system describes the transformation from six aspects: economic foundation, the situation of human capital, the ability of independent innovation, industrial structure adjustment and upgrading, resources and environment as well as people's living standards. Two methods of entropy weight and analytic hierarchy process (AHP) are used, respectively, to determine the weights of indicators for the purpose of high reliability. Comprehensive scores are calculated by the method of weighted average. The study reveals that China's industrial development mode has been changing gradually. The situation of human capital, the ability of independent innovation, the conditions of resources and environment as well as the standards of living are improved. Meanwhile, some issues in the process of transformation are still worthy discussing.

(1) Economic growth. EGI and the growth rate of industrial economy in China decreased twice under the circumstances of a noticeable slowdown of the world economy. The downturn means China's economic foundation, especially industrial economic foundation, is affected by the global economy obviously. China's ability of resisting external crisis is still weak. Therefore, the international and domestic economic situation should be paid close attention and never let the pace of transformation stagnant and even backward. In addition, there is no doubt that expanding domestic consumption demand is the important approach of resisting the economic crisis in the situation of China's economic growth which relies on foreign demand to a large extent [40,41]. Measures such as increase of people's income, reduction of tax burden of middle-low-income classes and unreasonable administrative expenses as well as government expenditure for capital construction, the expansion of people's livelihood expenditure should be considered [42,43] .

(2) Human capital. China's human resources are still at a low level. It is still unable to meet the needs of accelerating the transformation effectively. The figure of "Government appropriation for education/GDP" is consistently between 2.5% and 3.5%. In 2009, the figure reached 3.59% which was the highest point of those 10 years. However, it was still below the world average level of 4.5%. The target of reaching 4% in 2000, which was proposed firstly by the State Council in 1993 in China's Education Reform and Development Program [44] is not realized up to now. The indicators of "Number of professional technical personnel/Employment" and "Number of science & technology personnel/Employment" reflect that there is no significant improvement of China's personnel structure. The current personnel structure is still unable to provide strong support for the transformation. The measures of increasing educational input and developing higher education to improve the quality of human capital as well as paying full attention to the training of innovative and technical personnel should be taken.

(3) Independent innovation. It is worth to be considered that the constant increase of input and output in independent innovation are not the ultimate aims of transformation. China's ability of resisting external crisis is still not strong in enough and the profit of industrial enterprise increases insignificantly. It reveals that the achievements of independent innovation do not bring high returns for enterprises and the conversion rate of achievements is low. A difficult problem still remains, that is, how to pour the achievements into industrial enterprises and realize the industrialization of innovation achievements. The Chinese government should pay full attention to the importance of achievements conversion. The measures of increasing support strength to the enterprises' innovation activities and providing enterprises comprehensive services for innovation achievements conversion can be used to increase the conversion rate of achievements.

(4) Industrial structure adjustment and upgrading. Although the effect of industrial structure adjustment and upgrading from 2000 to 2009 is unsatisfactory, there is still a significant room for improvement in China. High technology industries, industrial upgrading, the integration of industrialization with information and the adjustment of high energy-consuming industries are still the critical points during the Twelfth Five-Year Plan period.

(5) People's living standards. When sharing the achievements of transformation, there are some concerns. Firstly, it is found that the growth rate of urban households' income in China is generally in line with GDP growth but the growth rate of rural households' income is always below the growth of GDP. It reflects that there is still a large gap between the income of urban area and rural area. The rural income level must be improved further. Secondly, it is unquestionable that the skyrocketing of housing price in China is the main obstacle of the improvement of people's living standards. The policy of limiting each family to only one house is unsustainable. This problem can be solved by reducing the local governments' over-reliance on the revenue from land sales, encouraging the local governments to look for the new economic increasing points, widening investment channels and improving the investment environment. Last but not least, the percentage of joining the basic pension insurance in rural areas is still as low as the level of 7–10%, and the rate in urban areas is always 3-4 times than that in rural areas. The problem of joining the basic pension insurance in rural areas is worth to be paid attention.

(6) Resources and environment. It is expected that with the reduction of the improvement space in resources and environment continuously, the difficulties of energy conservation and emissions reduction will be constantly increasing in the Twelfth Five-Year Plan period.

6. Conclusions

An index system is established and the transformation of China's industrial development mode from 2000 to 2009 is evaluated in this paper. China's industrial development mode has been changing gradually and our task of promoting the transformation has been progressing year by year. The situation of human capital, the ability of independent innovation, the conditions of resources and environment as well as the standards of living have been improving. However, there are some problems in the process of transformation: China's industrial foundation is affected by the global economy to a large degree, the ability of resisting external crisis is still not strong, and the effect of industrial structure adjustment and upgrading is unsatisfactory.

Besides, some prominent problems still remain in China that requires some further analysis, such as, the situation of human capital is still unable to meet the needs of transformation, the conversion rate of independent innovation achievements is not high, the housing price is relatively high, also the rich-poor divide in China posts a great threat.

Therefore, the Chinese government should take comprehensive measures to deal with above problems by expanding domestic consumption demand, increasing R&D investment and educational input, accelerating the conversion of independent innovation achievements and improving the standards of living.

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